Received: 25 January 2020 | Revised: 3 March 2020 | Accepted: 20 March 2020

DOI: 10.1002/ccr3.2840

CASE REPORT

Clinical Case Reports Open Access WILEY

Avoidance of bile duct injury during laparoscopic liver cyst fenestration using indocyanine green: A case report

Takehiko Hanaki | **Takuki Yagyu** | **Ei Uchinaka** | **Masaki Morimoto** | **Joji Watanabe** | **Naruo Tokuyasu** | **Shuichi Takano** | **Teruhisa Sakamoto** | **Soichiro Honjo** | **Yoshiyuki Fujiwara**

Division of Surgical Oncology, Department of Surgery, School of Medicine, Tottori University Faculty of Medicine, Yonago, Japan

Correspondence
Takehiko Hanaki, Division of Surgical Oncology, Department of Surgery, School of Medicine, Tottori University Faculty of Medicine, 36-1, Nishi-cho, Yonago, Tottori, Japan.
Email: hanaki-ttr@umin.ac.jp

Funding information
This report did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Abstract

By administering ICG test immediately before laparoscopic liver cyst fenestration, the biliary tract can be easily identified and intraoperative bile duct damage and postoperative bile fistula formation can be avoided, as demonstrated in this case.

KEYWORDS

bile duct injury, indocyanine green, laparoscopic fenestration for liver cyst

1 | INTRODUCTION

Here, we report a case of successful treatment of laparoscopic fenestration for giant hepatic cysts using indocyanine green (ICG). Observing ICG fluorescence excreted in the bile ducts after intravenous administration is a useful method to avoid the bile duct injury in laparoscopic cyst fenestration.

Nonparasitic liver cysts are congenital or acquired and are considered to be caused by an aberrant bile duct that has lost its communication with the normal biliary tree, which ultimately results in an isolated fluid-collected cavity in the liver.[1,2] Liver cysts are a relatively common disease with a prevalence of approximately 5%; however, the frequency of liver cysts has further increased because of the extension of life span in recent years and the increased use of imaging devices.[3,4] In most cases, liver cysts remain asymptomatic and do not require treatment.[2,5] However, treatment is required when the cyst increases in diameter and/or the patient experiences symptoms such as pain and abdominal distension. Two types of treatments, that is, nonsurgical and surgical, are used to manage liver cysts. Surgical treatments include fenestration procedures,[6,7] liver resection,[8] and liver transplantation.[9,10] Since the first report of laparoscopic fenestration (LF) for liver cysts in 1991,[11,12] the number of LF reports has increased year by year. LF is suitable as a minimally invasive procedure, and LF for liver cysts is now recognized as one of the standard therapies for treating symptomatic and nonparasitic liver cysts.[2,13]

One of the surgical advantages that can be attributed to LF is the sufficient fenestration that prevents the recurrence of the cyst. However, excessive resection of the cyst wall can increase the risk of bile leakage from the cut edge of the liver cyst.[14-16] This is because the fine bile ducts are not visible through the cyst wall in the majority of cases, and it is difficult to decipher all of them during fenestration.

Indocyanine green (ICG) clearance test is a well-established and one of the most reliable preoperative liver function tests.[17,18] Recent literature reports about the evaluation of tissue blood flow using ICG in various organs.[19,20] It is also known that ICG administered into blood is excreted in the bile.[21,22] This property has been used in a study to observe ICG excreted into the biliary tract for avoiding bile duct injury in a laparoscopic cholecystectomy.[21]

In this report, we describe a case of successful LF in a patient with symptomatic polycystic liver cysts using ICG to avoid bile duct injury, along with a review of literature.

2 | CASE PRESENTATION

A 67-year-old man was referred to our department. He had no past history of abdominal surgery and no family history of liver cysts and medication use. Liver cysts had been incidentally detected by ultrasonography 7 years ago, and he was being followed up regularly by a nearby doctor. There was no cyst in the kidneys. Although the liver cysts showed a gradual increase in diameter, the patient remained asymptomatic and was followed up regularly. However, as he developed swelling in his right flank, he was referred to our department. Laboratory data revealed normal levels of liver enzymes with no tumor markers, except that the ICG retention rate at 15 minutes (ICG-R15) was 25%. His liver function status was classified as Child-Pugh class A (5 points) and liver damage A. Computed tomography (CT) revealed multiple liver cysts, and thbe largest liver cyst was measured to be 20.2 × 16.2 × 15.9 cm in size (Figure 1A-B). The liver parenchyma around the cyst was displaced and deformed by the cysts. Drip infusion cholecystocholangiography CT showed bile ducts running through the thinned liver parenchyma between the cysts (Figure 1C). The patient was diagnosed with multiple cysts in the liver for which he underwent the LF procedure. To avoid bile duct injury during surgery, we decided not to fenestrate all cysts but to fenestrate only the largest one.

2.1 | Administration of ICG and operative technique

In our department, ICG-R15 is preoperatively assessed as one of the liver functions tests. In this patient, we performed the ICG-R15 test 1 hour before the surgery. ICG (Diagnogreen, Daiichi Sankyo Co.) was administered intravenously at a dose of 0.5 mg/kg. The ICG that was excreted into the bile duct[22] was detected by a laparoscopic imaging system using the Stryker PINPOINT system. A 12-mm trocar was placed at the umbilicus for scope passage, and 5-mm trocars were placed at the epigastric region and the right hypochondriac region for laparoscopic forceps. Cysts were observed on and inside the liver (Figure 2A-B). The cyst contents were punctured and drained outside the body. The cystic fluid did not exhibit ICG fluorescence (Figure 2C), and the biochemical test also showed no increase in bilirubin levels in the fluid. The ICG in the bile duct was observed as a linear ICG fluorescence. LF was performed using SonoSurg (Olympus). In the normal observation mode (Figure 3A), the intramural bile duct could not be identified; however, it was observed as a linear structure in the ICG mode (Figure 3B). Since there was bile outflow from the incision of the linear phosphor, it was confirmed that this was certainly a bile duct and the remaining liver side of the duct was clipped (Figure 3C). LF was performed as widely as possible to prevent recystization avoiding the intramural green fluorescence using the ICG mode. The operation was completed successfully, and the amount of bleeding during the operation was 2 mL. The volume of the cyst content fluid was 1900 mL, and the operation duration was 91 minutes.

2.2 | Postoperative clinical course

The patient recovered with no complication, and he was discharged on the fifth postoperative day. Histopathologically, the linear structure was also confirmed as an intramural bile

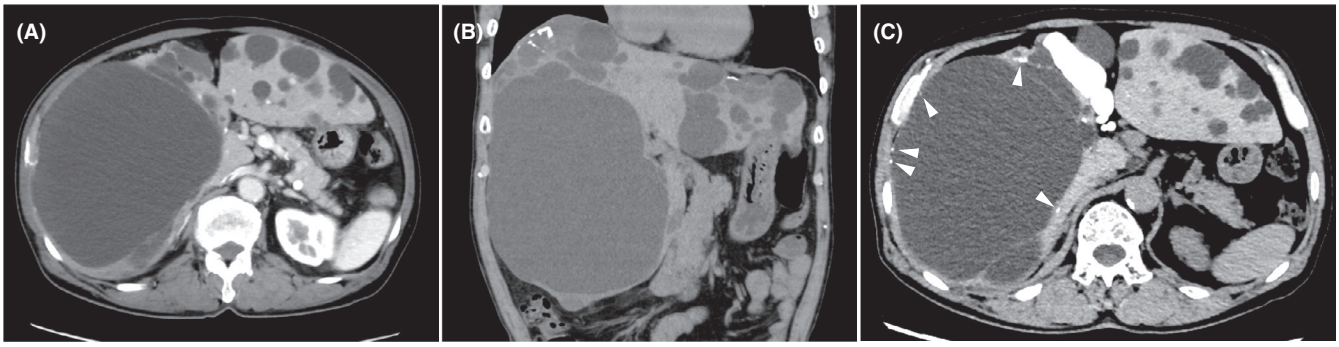


FIGURE 1 Preoperative images. Preoperative CT revealed large and multiple cysts in the liver in axial (A) and coronal (B) images. Drip infusion cholecystocholangiography CT revealed the contrast-enhanced intramural bile duct (arrowheads) in the thinned liver parenchyma between the cyst walls (C)

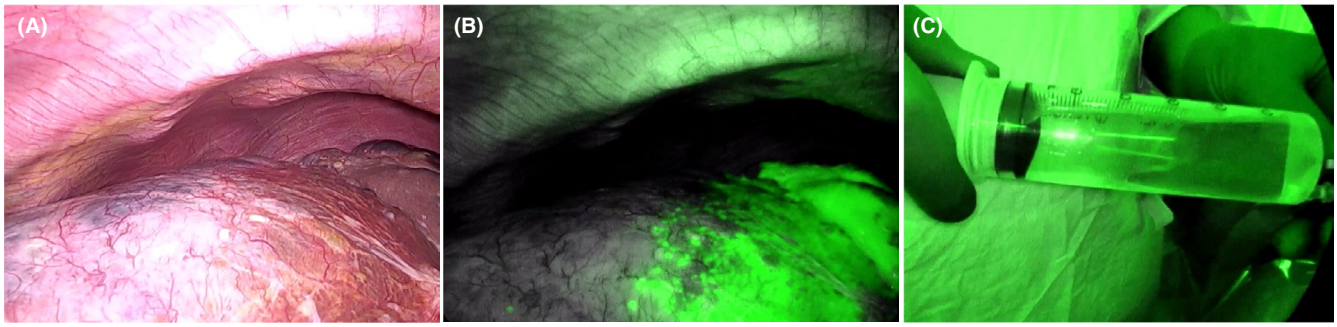


FIGURE 2 Intraoperative findings. Multiple cysts can be seen in the liver (A). The view of ICG-enhanced-fluorescence mode. There is no fluorescence in the cyst wall, whereas green fluorescence is observed in the liver parenchyma (B). ICG fluorescence was not observed in the puncture drainage fluid (B)

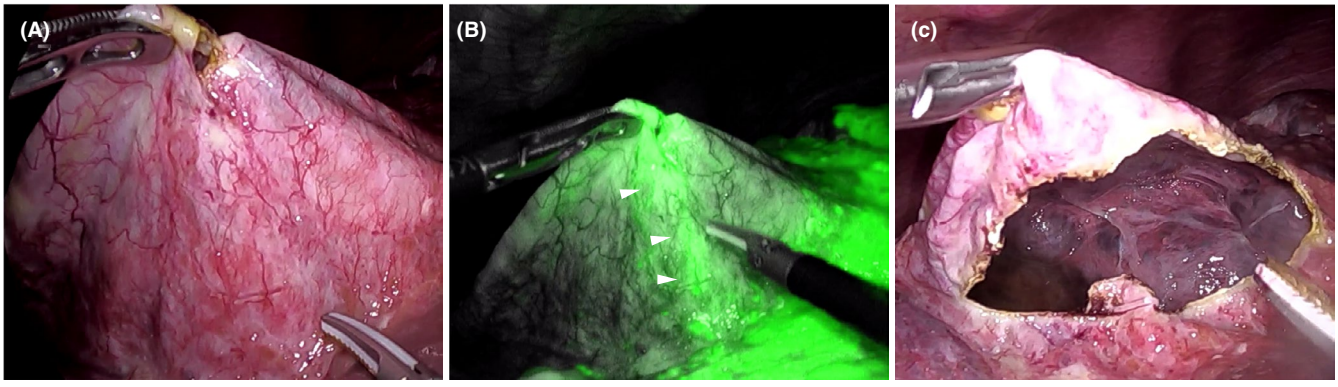
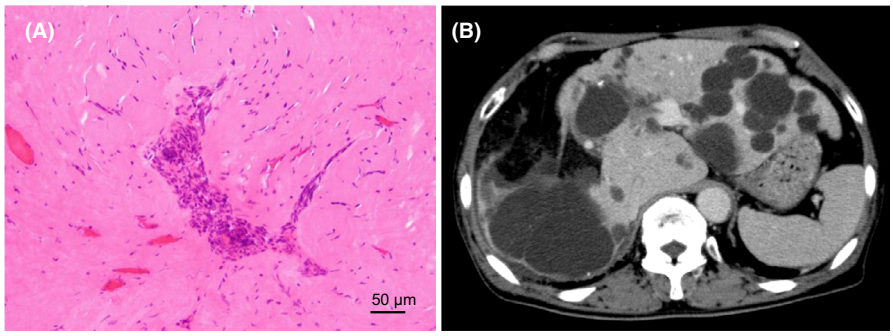


FIGURE 3 Operative views of the liver cyst wall. The intramural bile duct could not be identified using fluorescence normal light setting (A). Use of ICG-enhanced during laparoscopic cyst fenestration. The bile duct (arrowheads) in the cyst wall can be identified as a linear phosphor (B). Clipped intramural bile duct (C)

FIGURE 4 Postoperative findings. Hematoxylin and eosin staining of the linear phosphor. The linear structure was histopathologically confirmed to be a bile duct (A). CT performed 3 d after the surgery revealed no evidence of recystization of the fenestrated liver cyst (B). The omentum can be seen in the fenestrated cyst



duct (Figure 4A). CT performed 3 days after the surgery showed no recystization of the largest liver cyst (Figure 4B).

3 | DISCUSSION

Liver cysts are common with a prevalence of 2%–7% among the population and are typically discovered incidentally.[4] The pathogenesis of liver cysts is uncertain; however, as they are commonly observed in women, a correlation with estrogen levels has been suggested,[23] and symptomatic liver cysts are more common in females.[24]

Surgical options for treating symptomatic liver cysts include fenestration,[6,7] hepatectomy,[8] and liver transplantation.[9,10] Other treatment options include needle aspiration,[25] which is associated with a high recurrence rate, and sclerotherapy such as ethanol injection.[26] Since the first report of LF for liver cysts in 1991,[11,12] this procedure has been used as the standard method, although it has the risk of postoperative bile leakage.[16]

In addition to various liver function tests, ICG tests are generally performed to evaluate the safety of hepatectomy, and these tests are also adopted, for example, as criteria for assessing the degree of liver damage. The ICG test

was introduced and popularized by Makuuchi et al in the 1980s, especially in patients with hepatocellular carcinoma (HCC).[27,28] In patients with normal liver function, 95% of ICG is excreted into the bile duct after absorption by hepatocytes within 15 minutes.[29] In patients with impaired liver function, the excretion rate of ICG decreases and the timing of ICG when it can be observed in the bile would be delayed. The use of ICG in hepatobiliary surgery has become common, and its use to identify the biliary tree in hepatobiliary surgery has been reported. In 2008, Mitsuhashi et al reported for the first time that intravenously administered ICG can be used to visualize the bile duct during laparoscopic cholecystectomy.[30] Tanaka et al reported the first ICG usage in LF in 2016, and they had administered ICG 1 day before the surgery.

Usually, for visualizing a tumor, ICG is administered 24-48 hours before the surgery.[31] On the other hand, for fluorescent cholangiography, ICG is intravenously administered 0.5-24 hours before the surgery.[32,33] In our experience, intravenous administration of ICG 1 hour before the surgery was sufficient to successfully visualize the small bile duct in the cyst wall, and it also allowed us to avoid accidental bile duct injury. We followed this procedure based on a previous report that the maximum concentration of ICG in bile juice was observed within 2 hours after intravenous administration.[22] A comparative review of this case with previous reports is presented in Table 1. In our case, in addition to the sufficient ICG fluorescence in the liver parenchyma, bile juice fluorescence in the bile duct was observed without the need for an additional intraoperative ICG bolus injection. A previous report showed that ICG injected through an endoscopic nasobiliary drainage tube delineated the intrahepatic bile duct running in the cyst wall.[7] Therefore, this procedure can certainly be considered as an excellent method to identify a running biliary tract using fluorescent imaging; however, it is difficult to perform in all patients due to the invasive aspect of endoscopic nasobiliary drainage.

To our knowledge, this is the second report in the English literature showing that biliary tract damage could be avoided by administering preoperative ICG intravenously and observing the ICG excreted in the biliary fluorescence during LF. The limitations of using this test include the lack of knowledge about certain aspects such as the dose, timing, and volume of ICG administration according to the degree of liver damage. Moreover, ICG has the disadvantage of difficulty of delineating in case of a deep-lying intrahepatic bile duct because of its limited permeability. Nevertheless, in the case of liver cysts, the wall is so thin that this disadvantage could be overcome.

In conclusion, LF using intravenously administrated ICG that can visualize the intrahepatic bile duct located in the cyst wall is an effective method to reduce the risk of accidental bile duct injury during LF. Further study is needed

TABLE 1 Summary of previous studies using ICG during LF for liver cystsorrect one

No.	Author	Reported year	Age (year)	Sex	Timing of ICG administration	Amount of ICG administered (mg/kg)	ICG-R15 test	Additional bolus ICG	Operation duration (min)	Blood loss (mL)	Postoperative biliary fistula	Outcome after LF
1	Tanaka et al	2016	80	Female	1 d before the surgery	0.5	Normal	Yes (5 mg/body intraoperatively)	283	5	No	Discharged on the 6th postoperative day
2 (our case)	Hanaki et al	2020	67	Male	1 h before the surgery	0.5	25%	No	91	2	No	Discharged on the 5th postoperative day

Abbreviations: ICG, indocyanine green; ICG-R15, indocyanine green retention rate at 15 min; LF, laparoscopic fenestration.

to optimize the timing of ICG administration to confirm whether ICG fluorescence can help prevent and manage bile duct injury during LF. ICG fluorescence–guided LF has the potential to be used as a standard surgical procedure for treating symptomatic liver cysts.

CONFLICT OF INTERESTS

Authors have no conflicts of interest or financial ties to disclose.

AUTHORS' CONTRIBUTIONS

HT: gathered the patient data, performed a literature review, and wrote the manuscript. TY, EU, MM, JW, NT, ST, TS, and SH: revised the manuscript. YF: was involved in overall supervision of the paper. All authors: read and approved the final manuscript.

CONSENT FOR PUBLICATION

Written informed consent was obtained from the patient for the publication of this case report and accompanying images. A copy of written consent is available for review by the Editor-in-Chief of this journal.

ORCID


Takehiko Hanaki https://orcid.org/0000-0002-4008-0207

REFERENCES

1. Gevers TJ, Drenth JP. Diagnosis and management of polycystic liver disease. *Nat Rev Gastroenterol Hepatol*. 2013;10:101-108.
2. Loehe F, Globke B, Marnoto R, et al. Long-term results after surgical treatment of nonparasitic hepatic cysts. *Am J Surg*. 2010;200:23-31.
3. Caremani M, Vincenti A, Benci A, Sassoli S, Tacconi D. Ecographic epidemiology of non-parasitic hepatic cysts. *J Clin Ultrasound*. 1993;21:115-118.
4. Horton KM, Bluemke DA, Hruban RH, Soyer P, Fishman EK. CT and MR imaging of benign hepatic and biliary tumors. *Radiographics*. 1999;19:431-451.
5. Janssen YF, Haring MPD, Bastiaannet E, et al. Surgical treatment for non-parasitic liver cysts improves quality of life. *Surgeon*. 2019. https://doi.org/10.1016/j.surge.2019.09.008
6. Gigot JF, Jadoul P, Que F, et al. Adult polycystic liver disease: is fenestration the most adequate operation for long-term management? *Ann Surg*. 1997;225:286-294.
7. Kitajima T, Fujimoto Y, Hatano E, et al. Intraoperative fluorescent cholangiography using indocyanine green for laparoscopic fenestration of nonparasitic huge liver cysts. *Asian J Endosc Surg*. 2015;8:71-74.
8. Emre A, Serin KR, Ozden I, et al. Intrahepatic biliary cystic neoplasms: Surgical results of 9 patients and literature review. *World J Gastroenterol*. 2011;17:361-365.
9. Rawla P, Sunkara T, Muralidharan P, Raj JP. An updated review of cystic hepatic lesions. *Clin Exp Hepatol*. 2019;5:22-29.
10. Zhang Z, Hu K, Yang J, Zhou Y, Wang Z, Huang Y. Severe polycystic liver diseases: hepatectomy or waiting for liver transplantation? Two case reports. *Medicine (Baltimore)*. 2019;98:e18176.
11. Paterson-Brown S, Garden OJ. Laser-assisted laparoscopic excision of liver cyst. *Br J Surg*. 1991;78:1047.
12. Z'Graggen K, Metzger A, Klaiber C. Symptomatic simple cysts of the liver: treatment by laparoscopic surgery. *Surg Endosc*. 1991;5:224-225.
13. Kwon AH, Matsui Y, Inui H, Imamura A, Kamiyama Y. Laparoscopic treatment using an argon beam coagulator for nonparasitic liver cysts. *Am J Surg*. 2003;185:273-277.
14. Coelho-Prabhu N, Nagorney DM, Baron TH. ERCP for the treatment of bile leak after partial hepatectomy and fenestration for symptomatic polycystic liver disease. *World J Gastroenterol*. 2012;18:3705-3709.
15. Schnelldorfer T, Torres VE, Zakaria S, Rosen CB, Nagorney DM. Polycystic liver disease: a critical appraisal of hepatic resection, cyst fenestration, and liver transplantation. *Ann Surg*. 2009;250:112-118.
16. Tsirlis T, Thakkar R, Sen G, et al. Robotic fenestration of massive liver cysts using EndoWrist technology. *Int J Med Robot*. 2019;15:e1994.
17. Wakabayashi H, Ishimura K, Izuishi K, Karasawa Y, Maeta H. Evaluation of liver function for hepatic resection for hepatocellular carcinoma in the liver with damaged parenchyma. *J Surg Res*. 2004;116:248-252.
18. Lau H, Man K, Fan ST, Yu WC, Lo CM, Wong J. Evaluation of preoperative hepatic function in patients with hepatocellular carcinoma undergoing hepatectomy. *Br J Surg*. 1997;84:1255-1259.
19. Mangano A, Gheza F, Chen LL, Minerva EM, Giulianotti PC. Indocyanine green (Icg)-enhanced fluorescence for intraoperative assessment of bowel microperfusion during laparoscopic and robotic colorectal surgery: the quest for evidence-based results. *Surg Technol Int*. 2018;32:101-104.
20. Miyauchi W, Shishido Y, Kono Y, et al. Less invasive surgery for remnant stomach cancer after esophago-proximal gastrectomy with ICG-guided blood flow evaluation: a case report. *Yonago Acta Med*. 2018;61:187-191.
21. Ankersmit M, van Dam DA, van Rijswijk AS, van den Heuvel B, Tuynman JB, Meijerink W. Fluorescent imaging with indocyanine green during laparoscopic cholecystectomy in patients at increased risk of bile duct injury. *Surg Innov*. 2017;24:245-252.
22. Cherrick GR, Stein SW, Leevy CM, Davidson CS. Indocyanine green: observations on its physical properties, plasma decay, and hepatic extraction. *J Clin Invest*. 1960;39:592-600.
23. Maruyama Y, Okuda K, Ogata T, et al. Perioperative challenges and surgical treatment of large simple, and infectious liver cyst - a 12-year experience. *PLoS One*. 2013;8:e76537.
24. Cowles RA, Mulholland MW. Solitary hepatic cysts. *J Am Coll Surg*. 2000;191:311-321.
25. Moorthy K, Mihssin N, Houghton PW. The management of simple hepatic cysts: sclerotherapy or laparoscopic fenestration. *Ann R Coll Surg Engl*. 2001;83:409-414.
26. Wijnands TF, Schoenemeier B, Potthoff A, et al. Ethanol sclerotherapy or polidocanol sclerotherapy for symptomatic hepatic cysts. *United European Gastroenterol J*. 2018;6:919-925.
27. Makuuchi M, Kokudo N, Arii S, et al. Development of evidence-based clinical guidelines for the diagnosis and treatment of hepatocellular carcinoma in Japan. *Hepatol Res*. 2008;38:37-51.
28. Makuuchi M, Kosuge T, Takayama T, et al. Surgery for small liver cancers. *Semin Surg Oncol*. 1993;9:298-304.

29. Kawaguchi Y, Ishizawa T, Miyata Y, et al. Portal uptake function in veno-occlusive regions evaluated by real-time fluorescent imaging using indocyanine green. *J Hepatol*. 2013;58:247-253.
30. Mitsuhashi N, Kimura F, Shimizu H, et al. Usefulness of intraoperative fluorescence imaging to evaluate local anatomy in hepatobiliary surgery. *J Hepatobiliary Pancreat Surg*. 2008;15:508-514.
31. Alfano MS, Molfino S, Benedicenti S, et al. Intraoperative ICG-based imaging of liver neoplasms: a simple yet powerful tool. Preliminary results. *Surg Endosc*. 2019;33:126-134.
32. Verbeek FP, Schaafsma BE, Tummers QR, et al. Optimization of near-infrared fluorescence cholangiography for open and laparoscopic surgery. *Surg Endosc*. 2014;28:1076-1082.
33. Ishizawa T, Bandai Y, Ijichi M, Kaneko J, Hasegawa K, Kokudo N. Fluorescent cholangiography illuminating the biliary tree during laparoscopic cholecystectomy. *Br J Surg*. 2010;97:1369-1377.

How to cite this article: Hanaki T, Yagyu T, Uchinaka E, et al. Avoidance of bile duct injury during laparoscopic liver cyst fenestration using indocyanine green: A case report. *Clin Case Rep*. 2020;8:1419–1424. https://doi.org/10.1002/ccr3.2840